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MID-SCYTHIAN AMMONITES FROM IWAI FORMATION, JAPAN

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Lower Triassic ammonoids are known from only a few localities in Japan. The first fair-sized fauna to be recorded was that from the Taho formation on the island of Shikoku described by Yehara (1928). The majority of ammonite species from the Taho formation belong in *Anasibirites* and *Hemiprionites*; Yehara had erroneously assigned these ammonites to species of *Meekoceras*, *Kymatites*, *Ophiceras*, and *Xenodiscus*. This fauna is clearly representative of the zone of *Anasibirites multiformis*, which is known from Timor, Kashmir, the provinces of Kiangsu and Hupeh in China, British Columbia, Queen Elizabeth Islands, and western United States.

A most important contribution to our knowledge of the Lower Triassic of Japan was made by Sumio Sakagami who in 1955, described a small fauna of ammonites from the Iwai formation, Kaizawa Valley, Hinode-mura, Nishitama-gun, Tokyo-to. Sakagami had specimens from two fossiliferous beds, seventeen meters apart. The lower fauna was concluded to be of early Scythian age and the upper fauna to be mid-Scythian (*Meekoceras* zone) in age.

Correspondence between the authors about this fauna and the study of additional material bear out the conclusion that the faunas of both fossiliferous beds are of *Meekoceras* zone age. The object of this paper is to further document the species present and the age of the Iwai formation.

The Iwai formation is well exposed in the Kaizawa Valley where Sakagami has recognized four members. In ascending order these members are: (a) more than 40 m. of black and bluish sandstone, (b) 10 m. of shale, (c) 10 m. of sandstone, and

finally (d) about 25 m. of black shale which contains the two fossiliferous units. The lower fossil bed occurs about 2 meters above the base of the upper member, where the fossils occur in lenses of black limestone. The species identified from this horizon are:

Diencroceras iwaicense (Sakagami)

Diencroceras sp. indet.

Owenites shimizui (Sakagami)

Paranannites sp. indet.

Aspenites sp. indet.

Juvenites sp. indet.

The upper fossil bed lies about 17 meters above the lower fossil bed and consists of marl lenses from which Sakagami obtained a single specimen that has been assigned to *Aspenites*.

The genera and species in both the lower and upper beds are forms very characteristic of the mid-Scythian *Meckoceras* zone. Faunas of this age are well known from several localities in California, Nevada, Utah, and Idaho (Smith, 1932; Kummel, 1954); from the Queen Elizabeth Islands of Arctic Canada (Tozer, 1958); from the Island of Timor (Welter, 1922); from Southland, New Zealand (Kummel, 1959); from the northern Caucasus Mountains, Russia (Kiparisova, 1958); and finally faunas of this age appear to be represented in the Kolyma River region of northeastern Siberia (Popov, 1939) and in Yugoslavia (Petković and Mihajlović, 1935).

Of all the forms represented in the Iwai faunas the single specimen of *Owenites* furnishes the best clue as to their age. *Owenites shimizui* (Sakagami) is an immature form that, however, compares very closely with *Owenites koceni* from the *Meckoceras* beds of western United States. *Owenites* is also known from Timor, New Zealand, and the northern Caucasus Mountains, Russia. *Diencroceras* is a longer ranging genus but *Diencroceras iwaicense* (Sakagami) is close in its general conch morphology to *D. dicneri* from the *Meckoceras* beds of the western United States. The Iwai specimens placed in *Diencroceras* sp. indet. are more involute than *D. iwaicense* and of very different appearance. These specimens lack any sign of a suture and the identification can only be considered as tentative. *Juvenites* is another genus of widespread occurrence in the *Meckoceras* zone of western United States but it does range above and below this zone. The single specimen from the upper fossiliferous bed which Sakagami identified as *Aspenites* sp. was not available for study.

The specimen is fragmentary but appears from the illustration to be reasonably placed in *Aspenites*. Another specimen has been uncovered from the lower fossiliferous bed that is of much better preservation and is without any doubt an indeterminate species of *Aspenites*.

Previous assessments of the age of the Iwai formation rested largely on the identification of the most common species in the lower fauna — *Dieneroceras iwaiense* (Sakagami) — as an *Ophiceras*. Shimizu (1932) appears to have been the first to comment on the Iwai ammonites, though Fujimoto (1926) discussed some

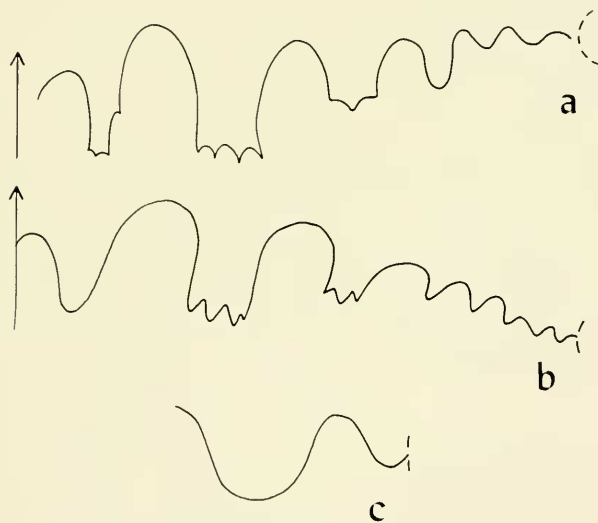


Fig. 1. Diagrammatic representation of the suture of (a) *Owenites shimizui* (Sakagami), holotype (from Sakagami, 1955, pl. 2, fig. 2c) X 7; (b) *Owenites koeneni* Hyatt and Smith, from a paratype of 15 mm. in diameter (from Hyatt and Smith, 1905, pl. 10, fig. 10), X 8; (c) *Dieneroceras iwaiense* (Sakagami), partial suture of holotype (from Sakagami, 1955, pl. 1, fig. 1c), X 10.

Pseudomonotis, earlier. Forms like *Dieneroceras iwaiense* are extremely difficult to place stratigraphically, and it was not until the presence of such genera as *Owenites* and *Aspenites* was established that both the age and generic assignment of the “*Ophiceras*” could be properly evaluated.

SYSTEMATIC DESCRIPTIONS

Family DIENEROCERATIDAE Kummel, 1952

Genus DIENEROCERAS Spath, 1934

DIENEROCERAS IWAENSE (Sakagami)

Plate 1, figures 3-5; Plate 2, figures 7-9

Ophiceras iwaiense Sakagami, 1955, pp. 135-136, pl. 1, figs. 1-9.*Ophiceras* sp. Sakagami, 1955, pp. 136-137, pl. 1, figs. 10-11.*Dieneroceras iwaiense*, Kummel, 1959, p. 430.

The dominant element in the lower ammonoid bed at Iwai is a new species of *Dieneroceras*. Sakagami (1955) had eleven specimens that he described and illustrated, and there are now four additional specimens in the collections of the Museum of Comparative Zoology. The conch is very evolute, each whorl embracing the preceding one only slightly. The whorls are compressed with broadly arched flanks which converge slightly toward the venter. The ventral shoulder is subangular and distinctly marked and the venter is a low broad arch. The umbilical shoulders are broadly rounded. The serpenticone coiling of the conch exposes all of the inner whorls which are more rounded (and less compressed) than the outer volutions. The conch is smooth, except that on some of the specimens there appear to be extremely faint radial folds. The measurements of the better preserved specimens are as follows:

	D	H	W	V
	(Measurements in mm.)			
*MCZ 5282a (Topotype)	22.5	7.7	5.3	11.0?
TUE 5255 (Paratype)	21.0	15.8	—	10.1
TUE 5254 (Paratype)	20.7	7.0	—	10.6
TUE 5252 (Paratype)	20.5	6.5	—	9.0
TUE 5257 (Paratype)	18.0	6.2	—	8.7
TUE 5251 (Holotype)	15.5	4.5	3.7	7.5
MCZ 5282b (Topotype)	15.0?	4.5	—	7.7
TUE 5256 (Paratype)	15.0	5.0	—	7.2
TUE 5253 (Paratype)	9.4	3.0	—	4.5

The suture is faintly and only partially visible on the holotype and on one of the paratypes and consists of a large first lateral lobe, and a much smaller second lateral lobe on the umbilical wall. It is not possible to determine whether or not the lobes are denticulated.

Remarks. Many of the mid- and late Scythian ammonoids, that have on various occasions been assigned to *Ophiceras*, are now commonly placed in *Dieneroceras* which is interpreted as a persisting generalized stock out of the early Scythian ophiceratids (Spath, 1934, p. 124; Kummel, 1952, p. 849, 852). In the *Meekoceras* fauna of western United States, *Dieneroceras* is represented by *D. dieneri* (Hyatt and Smith), *D. knochi* (Hyatt and Smith), *D. subquadratum* (Smith), and some as yet undescribed species. The specimens assigned by Smith (1932, p. 50, pl. 54, figs. 1-17; plate 56, figs. 13-18) to *Ophiceras sakuntala* Diener are also a species of *Dieneroceras*. As now interpreted the species assigned to *Dieneroceras* show a wide range in morphological features, especially marked in the cross-section of the whorls.

Dieneroceras iwaiense is morphologically most similar to the genotype, *D. dieneri*. This is especially noticeable in the angular ventral shoulders and low arched venter. The illustrations of the holotype and paratype of *D. dieneri* originally described by Hyatt and Smith (1905, pl. 8, figs. 16, 17, 19, 20) are inaccurate drawings; these types are re-illustrated here on Plate 3, figures 1-4. The Japanese species, however, is more compressed and the whorls converge toward the ventral region more than in *D. dieneri*. The genotype bears faint strigations which are most often not preserved, as already noted by Smith (1932, p. 49). None of the Japanese specimens show any trace of strigations.

Occurrence. Lower fossiliferous bed of upper member of Iwai formation, Kaizawa Valley, Iwai, Hinode-mura, Nishitama-gun, Tokyo-to, Japan.

Repository. MCZ 5282a,b,c, (Pl. 1, figs. 3-5); TUE 5254, paratype (Pl. 2, fig. 7); TUE 5251, holotype (Pl. 2, figs. 8, 9).

DIENEROCERAS sp. indet.

Plate 1, figure 1; Plate 2, figure 10.

Vishnuites sp. Sakagami, 1955, p. 137, pl. 1, fig. 12.

In the original collection described by Sakagami (1955), he had a single, small, incomplete specimen of which only one side of a half of a revolution was preserved (Pl. 2, fig. 10 of this report). Four additional, though fragmentary, specimens are now available. The best specimens are illustrated on Plate 1, figure 1. The cone is small, compressed, and involute; the whorl flanks are broadly arched merging with a well rounded umbilical

shoulder on the one side, but the ventral shoulders are sub-angular. The venter is broadly arched. The whorl sides bear weak, slightly sinuous, narrow folds which are most pronounced on the dorsal half of the whorl side. Unfortunately, no suture is preserved on any of the specimens.

Remarks. The incompleteness of the specimens and the absence of any sutures makes identification of forms like this extremely uncertain. The specimens could very possibly be juveniles of larger forms. Under these circumstances the assignment to *Dicnroceras* can only be considered as tentative but the most reasonable conclusion for the moment.

Occurrence. Lower fossiliferous bed of upper member of Iwai formation, Kaizawa Valley, Iwai, Hinode-mura, Nishitama-gun, Tokyo-to, Japan.

Repository. MCZ 5283 (Pl. 1, fig. 1); MCZ 5286 (unfigured specimens); TUE 5260 (Pl. 2, fig. 10).

Family PROPTYCHITIDAE Waagen, 1895

Subfamily OWENITINAE Spath, 1934

Genus OWENITES Hyatt and Smith, 1905

OWENITES SHIMIZUI (Sakagami)

Plate 2, figures 5, 6

Kingites shimizui Sakagami, 1955, pp. 138-139, pl. 2, figs. 2a c.

Owenites shimizui (Sakagami), Kummel, 1959, p. 430.

The holotype and only specimen of this species is a small, juvenile specimen that can with confidence be assigned to *Owenites*. The specimen measures 21.0 mm. in diameter, 11.3 mm. for the height of the last whorl, 8.0 mm. for the width of the last whorl, and the umbilicus is 1.5 mm. in diameter. The conch is involute with broadly arched whorl sides that converge, forming a sharp acute venter. The only ornamentation consists of radial growth lines.

The suture (Fig. 1a) is ceratitic and typical of that found in species of *Owenites*. It consists of a narrow, denticulated ventral lobe, a large denticulated first lateral lobe, a smaller second lateral lobe and a series of small auxiliary lobes. This suture is almost identical in its basic plan to that of a specimen of 15 mm. in diameter of *Owenites kocneni* Hyatt and Smith (1905, pl. 10, fig. 10) reproduced here on Figure 1b.

Remarks. Mature specimens of *Owenites* show marked excentrumbilication on the outer whorls producing a deep funnel-shaped umbilicus. The immature volutions (roughly up to 25-30

mm.) form a tightly involute couch and the small umbilicus shows no tendency toward excentrumbilication. *Owenites shimi-zui* is almost identical in couch shape and proportions to specimens of comparable size of *O. kocenui* of the *Meckoceras* zone of western United States. A paratype of *O. kocenui* originally illustrated by Hyatt and Smith (1905, pl. 10, figs. 7-9) by a poor drawing is illustrated here on Plate 3, figures 5-7. This specimen measures 15 mm. in diameter and is the specimen from which the suture of Text-figure 1b was obtained. The suture is very similar in these two species at about the same diameter, differing only in minor details. The resemblance to *Kingites* in couch shape and suture is more apparent than real.

Owenites is one of the best mid-Seythian zonal markers in the Circum-Pacific region. In western United States (California, Nevada, Utah, and Idaho) the genus is very common in the zone of *Meckoceras gracilitatus*. The genus was first established for specimens from the *Meckoceras* limestone in the Inyo range, California (Hyatt and Smith, 1905, p. 82). Smith (1932) recognized a number of additional species of *Owenites* in western United States but most of these appear to be merely intraspecific variants of *O. kocenui*.

The Timor *Owenites egrediens* Welter (1922) has a narrow, rounded keel-like venter formed by the shell, but the internal cast has a sharp venter. Likewise the Timor species is generally more inflated, producing a broader and deeper umbilical funnel. The suture also differs slightly in the shape of the lobes and the auxiliary series. Recently, a specimen of *Owenites* cf. *kocenui* Hyatt and Smith, has been described from beds of Pre-Etalian age in western Southland, New Zealand (Kummel, 1959). Outside of the Circum-Pacific region, *Owenites* has been recorded only from the northern Caucasus Mountains.

Occurrence. Lower fossiliferous bed of upper member of Iwai formation, Kaizawa Valley, Iwai, Hinode-mura, Nishitama-gun, Tokyo-to, Japan.

Repository. TUE 5262, holotype (Pl. 2, figs. 5, 6).

Family PARANANNITIDAE Spath, 1930

Subfamily PARANANNITINAE Spath, 1930

Genus PARANANNITES Hyatt and Smith, 1905

PARANANNITES sp. indet.

Plate 2, figures 1, 2

Proptychites aff. *rosenkrantzi* Spath, Sakagami, 1955, pp. 137-138, pl. 2, figs. 1a, b.

Paranannites sp. indet., Kummel, 1959, p. 430.

This form is represented by a single specimen of only moderate preservation. The conch is involute, compressed, with flattened, parallel whorl sides and a broadly rounded venter. It measures 33.1 mm. in diameter, 15.3 mm. for the height of the last whorl, 9.3 mm. for the width of the last whorl, and 6.5 mm. for the diameter of the umbilicus. Unfortunately no suture is preserved.

Lower Triassic ammonoids of this conch morphology are difficult to identify, and without the suture generally impossible to recognize. The fact that the associated fauna includes species of *Owenites* and *Juvenites* precludes the probability that this specimen could represent a species of *Proptychites*, which is generally an earlier Scythian form. The associated genera indicate a mid-Scythian age for the fauna and, of the ammonites of this age, *Paranannites* comes the closest in its conch morphology to this specimen from Iwai, Japan. *Paranannites aspicucensis* from the *Meckoceras* zone of western United States has a conch of the same degree of involution and rounded venter which, however, is more inflated—the whorl width being just slightly less than the whorl height. *Paranannites pectenuis* Smith (1932, p. 99, pl. 31, figs. 13-15) has a laterally compressed conch with flattened sides like the Iwai specimen (Pl. 3, figs. 9, 10). This species of Smith is believed to be a synonym of *P. aspicucensis*. The tentative placement of this specimen in *Paranannites* is, of course, based on the assumption that it is a mature specimen. If, however, it is a juvenile form it is most likely not a *Paranannites*, and then could possibly be the inner whorls of a *Flemingites* or *Arctoceras*, or other such larger ammonoids of mid-Scythian age.

Occurrence. Lower fossiliferous bed of upper member of Iwai formation, Kaizawa Valley, Iwai, Hinode-mura, Nishitama-gun, Tokyo-to, Japan.

Repository: TUE 5261 (Pl. 2, figs. 1, 2).

Genus JUVENITES Smith, 1927

JUVENITES sp. indet.

Plate 1, figure 2

The collection contains a single specimen in which only one side of a half volution is preserved. The specimen measures approximately 16.4 mm. in diameter, 7.3 mm. for the height of the last whorl, and the umbilicus is 5.0 mm. in diameter. The conch is involute with broad, depressed whorls and a broadly rounded

venter that grades imperceptibly onto the lateral areas. The conch bears very conspicuous forward projecting constrictions. There appear to be six such constrictions on the half volution. No indication of a suture is preserved.

Remarks. The lack of a suture and the incompleteness of the specimen necessarily make the present identification tentative. Even so, in consideration of the association with *Owenites* and *Aspenites* which are clearly mid-Scythian in age, the assignment of this specimen to *Juvenites* appears reasonable. The constrictions on the Iwai specimen are similar in depth and distinctness to those in *Juvenites septentrionalis* Smith (1932, pl. 31, figs. 31-32) but in the latter species the constrictions are radial. Strongly projected constrictions somewhat similar to those on the Iwai specimen are present on *Juvenites thermarum* (Smith, 1932, pl. 21, figs. 11-12, 16-17, 19-20).

Occurrence. Lower fossiliferous bed of upper member of Iwai formation, Kaizawa Valley, Iwai, Hinode-mura, Nishitama-gun, Tokyo-to, Japan.

Repository. MCZ 5284 (Pl. 1, fig. 2).

Family HEDENSTROEMIIDAE Waagen, 1895

Subfamily ASPENITINAE Spath, 1934

Genus ASPENITES Hyatt and Smith, 1905

ASPENITES sp. indet.

Plate 2, figures 3, 4; Plate 3, figure 8

Aspenites sp. Sakagami, 1955, p. 139, pl. 2, figs. 3a, b.

One of the authors (Kummel) has not had the opportunity to examine the single representative in the collection originally described by Sakagami (1955, p. 139) who states that it agrees with *Aspenites* of the western United States but the suture is not preserved. As well as one can tell from the illustration, this identification appears to be reasonably correct. Another specimen has since been uncovered from the lower ammonite bed that appears without doubt to be a juvenile representative of *Aspenites*. This specimen (MCZ 5285) measures only 8.0 mm. in diameter and is a completely involute conch, greatly compressed, with broad arched flanks which converge to a narrow, keeled venter (Pl. 3, fig. 8). No suture is preserved. The specimen is almost identical with specimens of comparable size of *Aspenites acutus* Hyatt and Smith (Smith, 1932, pl. 30, figs. 6-7, 9, 11-12).

Aspenites is fairly abundant in the *Meekoceras* beds of western United States and in Timor.

Occurrence. Both upper and lower fossiliferous beds of upper member of Iwai formation, Kaizawa Valley Iwai, Hinode-mura, Nishitama-gun, Tokyo-to, Japan.

Repository. TUE 5263 (Pl. 2, figs. 3, 4); MCZ 5285 (Pl. 3, fig. 8).

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